Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
UPDATES TO PARTS 2 AND 25 CONCERNING NON-GEOSTATIONARY, FIXED-SATELLITE SERVICE SYSTEMS AND RELATED MATTERS	)	IB Docket No. 16-408

COMMENTS OF SPACE EXPLORATION TECHNOLOGIES CORP.

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SUMMARY

Space Exploration Technologies Corp. ("SpaceX") commends the Commission for undertaking a review of its rules and policies governing non-geostationary satellite orbit ("NGSO"), Fixed-Satellite Service ("FSS") systems. Most of those rules were adopted over a decade ago, and are no longer appropriate when applied to the much larger and more technologically advanced NGSO constellations being proposed today. This proceeding affords an opportunity to ensure that the rules for NGSO FSS systems provide the necessary operational flexibility to allow innovative designs and business plans to flourish while also facilitating the spectrum sharing that will be critical to the success of this industry.

SpaceX supports the Commission's proposals to reinstate various secondary allocations and designations in the Ka-band for NGSO and geostationary orbit ("GSO") FSS satellite systems. These proposals would codify existing practices currently accomplished via waiver, increasing the opportunities for intensive spectrum use and providing additional resources and flexibility for FSS operations. They would also clear the way for the spectrum use proposed by NGSO FSS broadband constellations currently pending before the Commission (including the one filed by SpaceX). SpaceX does not support an alternative proposal that would elevate GSO to co-primary status, as introducing a new co-primary service in the only two bands where NGSO alone is designated as primary would upset settled expectations and reduce operational flexibility for NGSO systems.

The Commission should also update its rules in two ways to accommodate the new wave of large NGSO FSS constellations currently under development. First, SpaceX supports the *concept* of extending power flux-density ("PFD") limits to the additional portions of Ka-band spectrum in which NGSO operations would be allowed, as this could simplify the showing necessary

to ensure that an NGSO system is compatible with terrestrial operations throughout this band. However, extending the specific limits in Section 25.208(e) of the Commission's rules to additional bands would propagate a well-known technical flaw in the rule as applied to very large constellations. Specifically, the methodology used to calculate interference captures all satellites in the NGSO system, without any consideration to whether the satellites are in view of the victim terrestrial system or whether the satellites are turned on or off. This inclusion of all NGSO satellites in a constellation is a recognized flaw in the methodology at the Commission and internationally, especially when applied to systems with more than 840 satellites. Accordingly, SpaceX supports the Commission's interim proposal to deem a large NGSO system compliant so long as the aggregate PFD produced by the entire constellation at any point on Earth does not exceed a specified value, until such time as an appropriate alternative can be developed. This methodology would be a significant improvement, as it would recognize that PFD limits should only consider those satellites in view of the victim terrestrial system and those satellites actually in operation in order to assess potential interference at a given point on the Earth. However, SpaceX submits that the Commission should use the sliding scale in Section 25.208(e), rather than imposing a single limit of -115 dBW/m^2/MHz. This would establish a PFD of up to -105 dBW/m^2/MHz at high elevation angles, so that large constellations would not have to provide greater protection than would a single satellite.

Second, the requirement that an NGSO operator launch and begin operations of all satellites in its authorized constellation within six years of licensing may be impractical as applied to very large systems, and would not be necessary to promote the underlying policy objective of testing whether a licensee is committed to employing the licensed spectrum and orbital assets. The Commission has recognized that an NGSO operator may not need to launch every space station in its authorized

constellation in order to provide the services proposed in its application or demonstrate its commitment to deploy. SpaceX supports the Commission's proposal to modify the six-year milestone obligation for large constellations such that an operator would be required to launch and operate a portion of the authorized constellation sufficient to provide substantial service to the public. Rather than impose an arbitrary term of years for completing an NGSO constellation, SpaceX proposes phase objectives for constellation deployment up to the full number of satellites authorized once an NGSO licensee satisfies its initial deployment objective of providing service. Failure to achieve the level of deployment proposed for the relevant phase would be grounds for limiting the number of authorized satellites at the level of the constellation then in operation. This approach would assure that licensed spectrum and orbital assets are being put to productive use, allow market forces for the underlying service to dictate the pace of NGSO deployment once operations have begun, and ultimately cap the number of satellites in the system once operations reach a steady state.

With respect to spectrum sharing among NGSO systems, the Commission has found the in-line interference regime to be the best option available. Under this regime, an NGSO FSS system may operate using all authorized frequency bands except during "in-line events," which occur when satellites of different NGSO FSS systems appear to an earth station to be physically aligned at an angle of less than 10 degrees. SpaceX supports the Commission's proposal to apply this sharing mechanism to the Ku-band spectrum available for NGSO operations, to the bands in which NGSO FSS is currently designated as secondary, and to the bands proposed for NGSO FSS operation. In order to facilitate coordination for this purpose, NGSO operators should be given access to the ephemeris data maintained by the U. S. Strategic Command's Joint Space Operations Center, which would eliminate the need for each NGSO operator to post information about its own

system on the web. The Commission should also adopt rules that can create incentives for NGSO operators to design their systems with a range of advanced capabilities that facilitate spectrum sharing.

The Commission has adopted into its NGSO FSS rules certain international equivalent power flux-density ("EPFD") limits, which are designed to protect GSO operations. At present, however, these limits apply only with respect to uplink and downlink transmissions in the Ku-band. SpaceX supports the Commission's proposal to adopt the international EPFD limits applicable to NGSO FSS uplinks and downlinks in the portions of the Ka-band where NGSO operations are authorized or proposed to be authorized, and to inter-satellite transmissions in both the Ku- and Ka-bands. These international limits have become *de facto* domestic limits as well, and codification would have the added benefit of enabling global NGSO systems to implement a common strategy for system design and operation in all areas of the world.

By implementing the changes discussed above, the Commission will update its regulatory regime to better reflect the technological advances and increased size of today's NGSO FSS constellations, resulting in greater certainty and flexibility for system operators that will enable them to maximize productive use of valuable orbital and spectrum resources.

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COMMENTS OF SPACE EXPLORATION TECHNOLOGIES CORP.

Space Exploration Technologies Corp. ("SpaceX") hereby comments on the Notice of Proposed Rulemaking ("*NPRM*")[1] in which the Commission has proposed revisions to certain rules and policies governing satellite services, prompted by a planned new generation of large, non-geostationary satellite orbit ("NGSO"), Fixed-Satellite Service ("FSS") systems. SpaceX recently applied for authority to operate a large NGSO constellation of FSS satellites,[2] and that experience revealed several ways in which the rules – many of which have not been reviewed for over a decade – could be improved. SpaceX supports the Commission's efforts to update, clarify, and streamline its rules to facilitate the deployment of NGSO FSS systems and enable greater operational flexibility.

The NGSO FSS industry is dynamic and rapidly evolving to demonstrate its ability to provide critical communications services in the United States and internationally. As the applications filed in the currently ongoing processing rounds demonstrate, many NGSO operators

[1] *Updates to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 31 FCC Rcd. 13651 (2016) ("*NPRM*").

[2] *See* IBFS File No. SAT-LOA-20161115-00118 ("SpaceX NGSO Application").

are proposing diverse system designs and varied business plans in order to provide a wide array of services to customers around the world. The Commission's regulation of this industry should be shaped in such a way as to encourage these innovative NGSO design and operational strategies. At the same time, the rules should promote good spectrum stewardship so that multiple NGSO, geostationary orbit ("GSO"), and terrestrial systems can share spectrum resources while delivering services to the public. Adapting the rules to NGSO systems ranging from a several satellites to several thousand satellites presents a significant challenge. With the Commission's goals of spectrum efficiency and innovation, the number of satellites deployed is far less important than the radiofrequency characteristics of a given NGSO constellation. Because the Commission values spectral efficiency and sharing, its rules should create both opportunities and strong incentives for deployment of advanced and capable systems that feature the operational flexibility and technical agility needed to operate in an environment with multiple systems in the same spectrum bands.

I. THE COMMISSION SHOULD IMPLEMENT THE PROPOSED SECONDARY ALLOCATIONS AND DESIGNATIONS OF KA-BAND SPECTRUM

As explained in the *NPRM*, the initial plan for the Ka-band frequencies from 17.7-20.2 GHz and 27.5-30 GHz designated certain bands for licensing of NGSO FSS systems on a primary basis and GSO FSS systems on a secondary basis, and vice versa for other bands.[3] In 2000, the Commission revised this Ka-band Plan by eliminating the co-primary allocation for FSS in the 17.7-18.3 GHz band (leaving that band allocated solely to terrestrial Fixed Service ("FS") use) and deleting all of the secondary designations. Nonetheless, the Commission has granted waivers to allow FSS operations in the 17.7-18.3 GHz band and to allow GSO and NGSO systems to operate in spectrum designated for the other's use, on an unprotected, non-interference basis.[4]

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[3] *See NPRM* ¶ 4.

[4] *Id.* ¶ 6.

The *NPRM* proposes a series of changes to the U.S. Table of Frequency Allocations that would reinstate certain secondary FSS allocations and designations in the 17.8-20.2 GHz band. SpaceX supports this proposal. It would codify existing practices currently accomplished via waiver. It is better to recognize and codify operational reality rather than rely upon regulation by exception. In addition, it would formally enable the spectrum use proposed by NGSO FSS broadband constellations currently pending before the Commission (including the one filed by SpaceX).[5] This would increase the opportunities for intensive spectrum use and provide additional resources and flexibility for FSS operations. We discuss the specific proposal for each affected portion of the band in turn below.

17.8-18.3 GHz: The *NPRM* proposes to add a secondary FSS allocation to this band, which would give satellite system operators additional resources with which to work. It would facilitate frequency sharing among satellites by authorizing NGSO FSS systems in this band only on an unprotected, non-interference basis with respect to GSO FSS systems. SpaceX supports these aspects of the proposal.

The Commission also proposes that FSS use of the band would be limited in two ways. First, FSS operations would be subject to the applicable power flux-density ("PFD") limits adopted by the International Telecommunications Union ("ITU").[6] As discussed in Section II.A below, these PFD limits are flawed in that they systematically overestimate the potential for interference from a very large NGSO constellation. Yet SpaceX agrees with the Commission's conclusion that such PFD limits are sufficient to protect FS systems in the U.S. and obviate the need for further

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[5] *See, e.g.,* SpaceX NGSO Application, Waiver Requests at 11-13; IBFS File Nos. SAT-LOI-20161115-00108 (Telesat Petition at 31-32), SAT-LOA-20161115-00109 (Boeing Application at 35-36), SAT-LOI-20161115-00120 (ViaSat Petition at 15-18), and SAT-LOA-20161115-00121 (Theia Application at 41-43).

[6] *See NPRM* ¶ 9 (discussing ITU Radio Regulations, Article 21, Table 21-4).

coordination. Thus, a technically sound PFD limit could facilitate sharing between NGSO FSS and terrestrial systems. Recognizing this issue, the *NPRM* proposes an alternative PFD limit derived from the ITU rule, which better reflects the true effect of very large NGSO satellite constellations on FS operations. Assuming adoption of an appropriate PFD regime for this purpose, SpaceX would support such an approach.[7]

Second, the *NPRM* proposes that FSS deployment be limited to individually licensed earth stations, which it asserts "are more likely than ubiquitously deployed user terminals to be able to operate successfully on an unprotected basis with respect to primary FS stations."[8] While it may be true that some FSS systems may not be able to operate successfully in this band on an unprotected basis, others may be able to do so. Given that this limitation is not being imposed for the benefit of FS operators – whose systems are already protected by the PFD limits and are not threatened by receiving earth stations – there is no reason to deny FSS operators the ability to deploy user terminals in this band if they believe they will be able to operate successfully. Accordingly, this limitation should not be imposed.

Taken together, the proposed secondary allocation and adoption of appropriate PFD limits would make additional spectrum available on a streamlined basis for use by NGSO FSS systems willing to comply with safeguards protecting the services currently allocated in this band. Accordingly, assuming an appropriate adjustment to the flawed PFD regime and the ability to deploy earth stations on a blanket-licensed basis, SpaceX supports these proposals.[9]

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7 *See* discussion in Section II.B, *infra*.

8 *NPRM* ¶ 9.

9 Assuming revision of the flawed PFD methodology, these proposals are consistent with the proposed operation of SpaceX's NGSO system. *See, e.g.*, SpaceX NGSO Application, Waiver Requests at 10-12.

18.3-18.6 and 19.7-20.2 GHz: The *NPRM* proposes to add a secondary designation to allow NGSO FSS systems to operate on an unprotected basis with respect to GSO FSS networks currently designated as primary in these bands, subject to limits on equivalent power flux-density ("EPFD") applicable internationally under the ITU's rules.[10] These EPFD limits were specifically developed to ensure protection of GSO FSS networks from unacceptable interference by limiting NGSO transmissions in the vicinity of the GSO arc, and SpaceX agrees with the Commission that they should be sufficient to protect GSO networks. Here again, the proposal would provide NGSO satellite operators additional resources to the extent they can comply with safeguards protecting the services currently designated for the band, and SpaceX supports these changes.

18.8-19.3 GHz and 28.6-29.1 GHz: The *NPRM* raises two possibilities with respect to these bands.[11] First, it proposes to add a secondary designation to allow GSO FSS systems to operate on an unprotected, non-interference basis with respect to NGSO FSS networks currently designated as primary in the 18.8-19.3 GHz band. It also requests comment on the alternative of designating GSO FSS as co-primary with NGSO FSS in both of these bands. SpaceX supports the former proposal. Adding a secondary designation for GSO FSS systems in the 18.8-19.3 GHz downlink band would create additional operational flexibility for GSO operations and also match the current secondary GSO FSS designation in the paired 28.6-29.1 GHz uplink band. Moreover, it would do so while still maintaining the primary designation for NGSO FSS. By comparison, the alternative would undermine settled expectations of NGSO operators by depriving them of the only two bands where they have sole primary status. In addition, as the Commission notes,

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[10] *See NPRM* ¶ 10.

[11] *See id.* ¶¶ 11-12.

granting GSO FSS co-primary status would present significant coordination issues, since there are no EPFD limits in these bands.[12]

More generally, in the interest of clarity, the designations for use of Ka-band spectrum and restrictions on such use should both be codified as footnotes to the U.S. Table of Frequency Allocations, and reflected as entries in Section 25.202(a)(1) of the Commission's rules. In addition, rather than delete the "non-exhaustive" list in Section 25.202(a)(1) of spectrum allocated for FSS use,[13] the Commission should retain that list and update it as necessary to ensure that it is accurate and complete. Section 25.202 contains lists of frequencies available for many other satellite services, and the rules for many other services include similar lists.[14] Such lists provide an authoritative and readily accessible compilation of spectrum available to support specified operations. Anyone interested in designing an FSS system or evaluating FSS opportunities would have a much easier time doing so with the benefit of a list like that in Section 25.202(a)(1) rather than hunting through the table of allocations in search of relevant spectrum.

SpaceX does not object to use of the term "individually licensed earth station" as a replacement for "gateway earth station" in the footnote to Section 25.202(a)(1) related to certain Ku-band frequencies (10.7-11.7 GHz and 12.75-13.25 GHz), as this is more accurate and less open to interpretation. However, the use of this term should not affect the debate over whether to allow blanket licensed earth stations to operate in a given band, whether by waiver or by a future change in policy. As more NGSO systems deploy, and as advanced technologies such as beamforming continue to develop, there will be both a greater need for the ability to communicate with widely-

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12 *See id.* ¶ 12.

13 *See id.* ¶ 14 and n.43.

14 *See, e.g.,* 47 C.F.R. §§ 24.129 (narrowband PCS), 27.5 (WCS), 87.173 (HF and air traffic control), 97.301 (amateur), and 101.101 (fixed microwave).

deployed user terminals in more bands, and a greater ability to do so. Nothing about this proposed change in nomenclature should be viewed as an additional limitation on NGSO systems communicating with widely-deployed user terminals. Accordingly, if the Commission adopts the proposed change in terms for Section 25.208(a)(1), it should explicitly note that its action does not prejudge the deployment of user terminals in these bands.

II. THE COMMISSION SHOULD REVISE THE PFD LIMITS APPLICABLE TO LARGE NGSO FSS CONSTELLATIONS OPERATING IN KA-BAND SPECTRUM

The Commission has adopted different downlink PFD limits for different portions of the Ka-band spectrum used by FSS systems. The first set of limits, which applies across the 18.3-18.8 GHz band (among others), is set forth in Section 25.208(c) of the Commission's rules, and establishes specific limits based on the angle of arrival of the transmission from the satellite to the receiving earth station. The second, set forth in Section 25.208(e) of the Commission's rules, includes PFD limits for NGSO systems operating in the 18.8-19.3 GHz band that vary based on the angle of arrival *and* the number of satellites in the NGSO constellation. This second set of PFD limits, in Section 25.208(e), are identical to the limits in Article 21 of the ITU Radio Regulations, which apply across the entire 17.7-19.7 GHz band.

In light of the proposals to allow NGSO operations in additional portions of the Ka-band, the *NPRM* proposes to extend the PFD limits in Section 25.208(e) to the 17.8-18.6 GHz and 18.8-19.7 GHz bands.[15] SpaceX supports this proposal in concept, as specifying a PFD limit will simplify the showing necessary to ensure that an NGSO system is compatible with FS operations throughout this band. However, extending the existing rule to additional bands would propagate a technical flaw in the rules as applied to very large constellations. Specifically, the methodology used to

[15] *NPRM* ¶ 16.

calculate interference is expressed as a function of the number of satellites in the NGSO system, without any consideration of whether the satellites are in view of the victim FS system or whether the satellites are turned on or off. As discussed below, this inclusion of all NGSO satellites in a constellation is a recognized flaw in this calculation, especially when applied to systems with more than 840 satellites. Accordingly, SpaceX supports the Commission's proposal to apply an aggregate PFD limit until such time as an appropriate EPFD limit can be devised, though the specific limit proposed should be adjusted slightly.

A. The Existing PFD Limit Methodology is Flawed as Applied to Large NGSO Constellations

The PFD limits in Section 25.208(e) were imported directly from the ITU's Article 21,[16] and are stated as follows:

$-115 - X$	dB(W/(m^2 ·MHz)) for $0° \le \delta < 5°$
$-115 - X + ((10 + X)/20)(\delta - 5))$	dB(W/(m^2 ·MHz)) for $5° \le \delta < 25°$
-105	dB(W/(m^2 ·MHz)) for $25° \le \delta < 90°$

where δ is the angle of arrival above the horizontal plane and X is a "scaling function" defined based on the number of satellites in the NGSO FSS constellation, n, as follows:

for $n \le 50$	$X = 0$	(dB)
for $50 < n \le 288$	$X = (5/119)\ (n - 50)$	(dB)
for $n > 288$	$X = (1/69)\ (n + 402)$	(dB)

These PFD limits were developed in the study cycle prior to WRC-2000 and formalized in ITU Recommendation SF.1483,[17] at a time when proposed NGSO systems featured far fewer satellites. That recommendation makes clear that the scaling function that depends upon the absolute number

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[16] *See Redesignation of the 17.7-19.7 GHz Frequency Band*, 15 FCC Rcd. 13430, ¶ 86 and Appendix A (2000).

[17] *See* "Maximum Allowable Values of PFD Produced at the Earth's Surface by Non-GSO Satellites in the FSS Operating in the 17.7-19.3 GHz Band," Rec. ITU-R SF.1483 (2000) ("Rec. SF.1483").

of satellites in the constellation "was developed on the basis of non-GSO FSS satellite constellations with 96, 288 and 840 satellites,"[18] with no consideration of how this scaling function could distort application of the limits to even larger NGSO constellations. In addition, the underlying analysis was based upon a number of very conservative assumptions that were recognized to result in calculated PFD levels much higher than an actual system would produce.

> It must be noted that the pfd mask analysis is overly conservative in that it computes interference (both long-term and short-term) that exceeds what would be produced by an operating non-GSO FSS system. This is because the analysis assumes that all the visible satellites of the non-GSO FSS satellite constellation radiate simultaneously the maximum pfd limit, in the direction of the FS system under consideration, which is unrealistic. In addition, such an assumption does not take into account the patterns of the real satellite antenna, the power limitations of each satellite or the restrictions that self-interference would impose on a non-GSO satellite system.[19]

As a result, the recommendation itself states that "[a]nalyses taking into account the actual operational characteristics of the non-GSO network have shown that substantially lower aggregate power flux-density (apfd) levels will be produced."[20] SpaceX concurs with this conclusion.

In his report to WRC-15, the Director of the ITU's Radiocommunication Bureau recognized the flaw in the scaling methodology in Article 21 for PFD calculations and highlighted it for the Conference. Specifically, with respect to the scaling function that had been developed based on NGSO constellations with no more than 840 satellites, he noted that current PFD limits may become very low for recently-filed constellations with significantly more satellites, leading to a conclusion that such systems exceed the limit.[21] This is because strict application of the

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[18] *Id.* at Annex 1, Sec. 5.

[19] *Id.* at Annex 1, Sec. 3.

[20] *Id.* at Note 3.

[21] *See* Director, Radiocommunication Bureau, "Report of the Director on the Activities of the Radiocommunication Sector, Part 2 – Experience in the Application of Procedures and Other Related Matters (rev. 1)," at 29 (Sep. 29, 2015), *available at* http://www.itu.int/md/R15-WRC15-C-0004/en.

equation in Article 21 (and Section 25.208(e)) would consider energy transmitted by all satellites in a very large NGSO constellation, rather than only those in view, which are the only satellites that would actually contribute simultaneously to potential interference at a given point on the Earth. As a result, this methodology significantly overestimates the potential for interference to terrestrial FS systems.

Accordingly, the Director advised that the Conference should "consider[] reviewing or confirming the pertinence of the assumptions that lead to the current values of Articles 21 and 22 power limits" in light of the characteristics of these recently-submitted systems.[22] However, the WRC-15 Conference took no action to address the flawed PFD calculations and the ITU rules have not yet been modified to reflect more realistic protection levels where very large NGSO constellations are involved. SpaceX urges the Commission to pursue the development of a more appropriate PFD methodology or some alternative approach, not only for its own rules but also as a revision of the ITU rules.

B. The Interim PFD Approach Proposed in the *NPRM* Would Better Serve the Public Interest Than the Flawed PFD Limit that Currently Applies

Undertaking the technical analysis and consensus building necessary to develop a new PFD or EPFD limit to apply to large NGSO FSS constellations, both domestically and internationally, could easily take several years.[23] The Commission should not suspend its current consideration of

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22 *Id.* at 30.

23 For example, the EPFD limits currently codified in Article 21 of the ITU Radio Regulations were years in the making. Values were initially proposed in the study cycle leading up to WRC-97. WRC-97 adopted a set of provisional values which were then reviewed in the study cycle leading up to WRC-2000, where final values were ultimately adopted. The Commission then adopted those rules domestically in December of that year. *See Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range*, 16 FCC Rcd. 4096, ¶¶ 12-15, 19-20 (2000). More recently, WRC-15 undertook studies to develop PFD and EPFD limits for C-band frequencies to be considered at WRC-19. *See* ITU-R Res. 157 (WRC-15).

applications for authority to operate NGSO FSS systems that implicate the limits in Section 25.208(e) until such time as a new PFD or EPFD regime has been developed and adopted.[24]

As an interim measure, the *NPRM* proposes to deem a proposed NGSO system compliant with Section 25.208(e) so long as the aggregate PFD produced by the entire constellation at any point on Earth does not exceed -115 dBW/m^2/MHz. This methodology would be a significant improvement, as it would recognize that only those satellites in view and in operation, which could actually contribute simultaneously to potential interference at a given point on the Earth, should be considered for purposes of this PFD limit.

Yet the approach proposed in the *NPRM* has a flaw of its own. Compared to the methodology for the PFD limit set forth in Section 25.208(e), the interim approach would effectively require large NGSO constellations to comply in the aggregate with the limit applicable to relatively small NGSO constellations at very low angles of arrival, but would impose increasingly more stringent PFD limits at higher angles of arrival than those smaller systems face. For example, assume the simple (and extreme) case of an NGSO system with a single satellite. Under the formula in Section 25.208(e), that single satellite would not be allowed to exceed -115 dBW/m^2/MHz for angles of arrival less than five degrees or -105 dBW/m^2/MHz for angles of arrival greater than twenty-five degrees, with the limit increasing from the former figure to the latter at angles of arrival in between. Under the proposal in the *NPRM*, a large NGSO constellation could be deemed compliant with the PFD limit if the aggregate energy from all transmissions at

[24] With regard to the development of EPFD limits in general, SpaceX supports the Commission's proposal to delete the first sentence of Section 25.156(d)(5), which, in spectrum for which the Commission has not yet adopted criteria for GSO/NGSO sharing, precludes the grant of an NGSO license where a GSO license has previously been issued, and vice versa. *See NPRM* ¶ 21. Applicants should have the flexibility to make a compatibility showing for assessment by the Commission even before formal sharing rules have been adopted. Indeed, for the same reasons, SpaceX supports deletion of the second sentence as well.

any point on the Earth's surface does not exceed the most restrictive limit applicable to a single satellite – *i.e.*, -115 dBW/m^2/MHz – for *all* angles of arrival.

There is no reason why large NGSO systems should be held to a more stringent interference standard than smaller NGSO systems. The Commission and ITU have each determined that allowing NGSO systems to generate the PFD level specified in the rule is consistent with its intended purpose of protecting terrestrial FS systems against potential interference from satellite downlink transmissions. By applying only the most restrictive PFD level applicable to any angle of arrival, the proposed approach would significantly over-protect FS operations and unnecessarily limit large NGSO systems. SpaceX submits that the Commission should revise its interim proposal such that a large NGSO system will be deemed compliant with Section 25.208(e) so long as the aggregate PFD produced by the entire constellation at any point on Earth does not exceed the PFD level set forth in Section 25.208(e) for the relevant angles of arrival. By taking this more realistic approach, this interim proposal would strike an appropriate balance that protects FS systems while also granting greater flexibility to large NGSO constellations.

In this regard, SpaceX submits that in applying this and other PFD limits, the Commission should also recognize that the size of a given NGSO constellation is likely to vary over time, most dramatically in the early years of initial deployment. Accordingly, the Commission should specify that PFD limits are to be determined dynamically based on the number of satellites actually in operation at a given time, versus a static limit based on the worst-case assumption that all satellites authorized for a constellation are operating. This would enable NGSO FSS operators during the initial phases of deployment to utilize all available power within the PFD limit, whether to provide greater coverage or increased capacity, without the artificial constraint of imputed interference from satellites not yet in orbit. FS operators would face no greater risk of potential interference

from this approach because the NGSO system would never exceed the PFD limits at any point during its deployment. This simple adjustment in application of PFD limits would therefore better serve the public interest by enabling NGSO systems to provide more and better service to customers without any offsetting adverse consequences to other authorized spectrum users.

III. THE COMMISSION SHOULD MODIFY ITS LAUNCH AND OPERATION MILESTONE TO BETTER REFLECT THE NATURE OF NGSO CONSTELLATIONS

Under the Commission's rules, all satellites authorized in an NGSO constellation must be launched and begin operations within six years of license grant.[25] The Commission has established such milestone requirements for satellite system implementation in order to deter warehousing, which in this context "refers to the retention of preemptive rights to use spectrum and orbital resources by an entity that does not intend to bear the cost and risk of constructing, launching, and operating an authorized space station, is not fully committed to doing so, or finds out after accepting the license that it is unable to fulfill the associated obligations."[26] The rules are intended to offset the incentives for warehousing that could harm both competition and consumers, while also encouraging the rapid deployment of new spacecraft and the optimal utilization of scarce orbital and spectrum resources.[27]

Yet, as the Commission recognizes, an NGSO operator may not need to launch every space station in its authorized constellation in order to meet the rule's expressed objective of demonstrating full commitment to deploy a constellation, nor even to provide the services

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[25] *See* 47 C.F.R. §§ 25.137(d)(1) (milestone for non-U.S. licensees), 25.164(b) (milestone for U.S. licensees).

[26] *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, 30 FCC Rcd. 14713, ¶ 53 (2015) ("*Part 25 Second R&O*").

[27] *Id. See also, e.g., Amendment of the Commission's Space Station Licensing Rules and Policies*, 18 FCC Rcd. 10760, ¶ 173 (2003); *TerreStar Networks, Inc.*, 22 FCC Rcd. 17698, ¶ 6 (IB 2007).

proposed in its application. For example, a constellation could begin initial service with fewer satellites and then deploy additional satellites (up to its full authorization) to increase coverage, capacity, and reliability over time as demand increases. Accordingly, in order to afford operators greater flexibility with system design and implementation, the Commission proposes to modify the six-year milestone obligation for NGSO systems such that an operator would be required to launch and operate a portion of the authorized constellation sufficient to provide substantial service to the public.[28] An operator that meets this first milestone would then be required to launch and operate all satellites authorized in its constellation within nine years of grant.

SpaceX applauds the Commission for recognizing that the same sort of one-size-fits-all milestone regime may not be appropriate for individual GSO satellites, smaller NGSO systems, and larger NGSO constellations. Launch and operation of a GSO satellite is a significant achievement, but it culminates in a singular act that is easy to define and assess. Launch and operation of a small NGSO system involves a greater number of events, but evaluating completion of that goal is still likely to be a straightforward exercise. By contrast, large NGSO systems may involve hundreds or thousands of satellites, but beyond anticipated initial demand, their further deployment may be incremental in order to add coverage or capacity over time to track growth in demand for services. Simply designing, constructing, and deploying even the initial stage necessary to begin operations of a large NGSO constellation will require a very significant investment of resources – considerably more than reasonably sufficient to demonstrate that the licensee is "fully committed" to bearing the cost and risk of operating its authorized system.[29]

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[28] *NPRM* ¶ 32. For this purpose, the *NPRM* tentatively concludes that 75% of the authorized constellation would be an appropriate milestone figure.

[29] *See Part 25 Second R&O*, ¶ 53.

Indeed, these initial deployments may require greater investment of resources than complete deployment of many smaller systems. Beyond meeting the standard needed to allay fears of spectrum warehousing, further constraining NGSO operators' flexibility to deploy against shifting demands for capacity or coverage would not serve the public interest.

Accordingly, SpaceX supports the proposal to require an applicant for a large NGSO constellation to state the minimum number of satellites necessary to provide the services it proposes.[30] Under this approach, an applicant for authority to operate a constellation of appropriate size, or to use such a constellation to serve the U.S. market, would state the minimum number of satellites with which it intends to begin its intended service. The Commission could then apply the familiar "substantial service" standard applied to many terrestrial wireless services, including several that operate in the same Ku- and Ka-band spectrum as NGSO FSS systems.[31] This would ensure that the service level supported by the number of satellites proposed would be "sound, favorable, and substantially above a level of mediocre service."[32] Launching a sufficient number of satellites to begin provision of service would ensure that valuable spectrum and orbital resources are put to use in a timely manner, consistent with the purpose underlying the milestone requirement.

After meeting this initial deployment objective, an NGSO licensee should be required to propose phase objectives for deployment (up to the maximum originally authorized) going forward based on the development plan for its system. In order to ensure steady progress, each such

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[30] *NPRM* ¶ 33. SpaceX also supports the Commission's proposal to clarify that NGSO replacement satellites are not subject to any milestone requirements. *Id.* ¶ 34.

[31] *See, e.g.*, 47 C.F.R. §§ 101.1011(a) (Local Multipoint Distribution Service), 101.1413(b) (Multichannel Video and Data Delivery Service).

[32] *See, e.g.*, *id.* § 27.14(a).

proposal should add materially to the coverage or capacity of the overall constellation at least every three years. Failure to achieve the level of deployment proposed for the relevant phase would be grounds for the Commission to consider limiting the number of authorized satellites to the level of the constellation then in operation.[33] This approach is more appropriate than establishing an arbitrary term of years in which to launch and operate the entire constellation authorized, no matter the size. It would assure that licensed assets are being put to productive use, allow market forces to dictate the pace of deployment once operations have begun, and ultimately cap the number of satellites in the system once operations reach a steady state.

IV. THE COMMISSION SHOULD EXTEND THE AVOIDANCE OF IN-LINE EVENTS SPECTRUM SHARING MECHANISM TO ADDITIONAL BANDS AND MAINTAIN THE SPACING TRIGGER AT TEN DEGREES

Section 25.261 codifies one default mechanism for intra-service spectrum sharing among NGSO FSS systems. Under this mechanism, an NGSO FSS system may operate throughout its authorized band except during "in-line" events, which occur when satellites of different NGSO FSS systems are physically aligned with an operating earth station of one of those systems, such that the angle between the satellites is less than 10 degrees as measured from the earth station. During such an in-line event, the rule requires the affected satellite operators to divide the commonly assigned spectrum equally, unless they can reach some other arrangement.

[33] An operator would be able to seek a waiver for delays due to events beyond its control, such as launch or satellite failures, or for other good cause.

A. Extending the Rule to Additional Bands Would Promote Consistency and Clarity in the Commission's Rules for NGSO Operations

The Commission first adopted this approach in 2002, with respect to Ku-band NGSO FSS systems,[34] and then applied this same approach to Ka-band NGSO FSS systems a year later.[35] However, the rule as codified in Section 25.261 applies only to the Ka-band, and in particular to the 18.8-19.3 GHz and 28.6-29.1 GHz frequency bands. Nonetheless, since that rule was adopted, the Commission has applied this in-line avoidance sharing technique in other portions of the Ka-band as well.[36] Moreover, it has also issued all Ku-band NGSO FSS system authorizations with a similar condition based on avoidance of in-line events,[37] and has issued a public notice to clarify "that the text in Section 25.261 for Ka-band NGSO FSS systems also describes the same sharing criteria the Commission adopted for Ku-band systems."[38]

SpaceX supports the Commission's proposal to add the Ku-band spectrum available for NGSO operations to the list covered by Section 25.261. This will officially rectify the omission of those frequencies and clarify the application of the in-line interference regime. SpaceX also supports the proposal to add to this list the bands in which NGSO FSS is currently designated as secondary as well as the bands proposed in the *NPRM* for NGSO FSS operation.[39] As the

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[34] *See Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, 17 FCC Rcd. 7841 (2002) ("*Ku-band NGSO Sharing Order*"). For this purpose, "Ku-band" refers to the 10.7-12.7 GHz, 12.75-13.25 GHz, and 13.75-14.5 GHz frequency bands.

[35] *See Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band*, 18 FCC Rcd. 14708, ¶¶ 18-21 (2003) ("*Ka-band NGSO Sharing Order*").

[36] *See Northrop Grumman Space & Mission Systems Corp.*, 24 FCC Rcd. 2330, ¶¶ 32-33 (IB 2009) ("*Northrop Grumman*") (extending in-line avoidance sharing technique to 19.7-20.2 GHz and 29.5-30.0 GHz bands).

[37] *See SkyBridge L.L.C.*, 20 FCC Rcd. 12389, ¶ 74 (IB 2005); *Virtual Geosatellite, LLC*, 21 FCC Rcd. 14687, ¶ 91 (IB 2006).

[38] *See International Bureau Provides Guidance Concerning Avoidance of In-Line Interference Events Among Ku-Band NGSO FSS Systems*, 30 FCC Rcd. 11534 (IB 2015).

[39] *See NPRM* ¶ 23.

Commission has found, the in-line interference regime offers the best methodology for intra-service spectrum sharing,[40] and is much preferable to a simple spectrum splitting approach such as that in Section 25.157.[41] To the extent NGSO FSS systems operate in these bands, this approach should be applied consistently. In addition, as proposed in the *NPRM*, the Commission should clarify that Section 25.261 applies only to NGSO FSS systems communicating with earth stations that employ directional antennas. Systems with non-directional earth station antennas should be allowed only if the applicant can prove that the system does not interfere with the other NGSO systems under any circumstances, including during in-line events.[42]

As the Commission notes, NGSO operators must know the location of co-frequency NGSO space stations in other constellations in order to effectuate the avoidance of in-line events sharing mechanism. Section 25.271(e) of the Commission's rules requires NGSO FSS licensees in the 10.7-14.5 GHz band to maintain a website with ephemeris data for each satellite in its constellation, which may facilitate coordination for this purpose.[43] However, that rule does not cover all bands used (and proposed to be used) for NGSO operations, nor does it cover non-U.S. licensed systems serving the U.S., leaving potential gaps in the regulations. If there is to be a requirement to provide ephemeris data, SpaceX agrees that the Commission should extend it to apply (1) with respect to the Ka-band spectrum currently allocated to NGSO FSS operations on a primary or secondary basis, as well as the Ka-band spectrum proposed for NGSO FSS operations in this proceeding, and

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40 *See Ku-band NGSO Sharing Order*, ¶¶ 27-32; *Ka-band NGSO Sharing Order*, ¶¶ 18-21.

41 *See* 47 C.F.R. § 25.157(e) (spectrum to be divided equally among NGSO licensees whose applications are granted in the same processing round).

42 *NPRM* ¶ 23.

43 *See* 47 C.F.R. § 25.271(e).

(2) to non-U.S. licensed systems granted U.S. market access.[44] In addition, any such rule should require that ephemeris data be updated more frequently than once every three days, as required under Section 25.271(e). As more and larger constellations begin operation, having more accurate and current information becomes ever more imperative.

SpaceX believes that there is a better way to access ephemeris data than requiring NGSO FSS system operators to post it on a website. This information should be available through a single authoritative source, rather than through a number of disparate web sites. One option would be to utilize the resources of the U. S. Strategic Command's Joint Space Operations Center ("JSpOC"), which currently detects, tracks, and identifies all artificial objects in Earth orbit, and conducts a conjunction analysis for all active spacecraft on a routine basis. In the near future, it will bring online a new system known as the "Space Fence" with the capability to track ten times the number of space objects with better accuracy, precision, and timeliness.[45] NGSO operators should be given access to that data, which would eliminate the need for those operators to post information on the web with respect to their own systems.

B. The Ten-Degree Trigger Properly Accommodates Service to Individual Users and Should Be Maintained

The *NPRM* also seeks comment on whether the ten-degree separation angle trigger for the in-line event mechanism should be increased or decreased to reflect NGSO system designs.[46] At the outset, it is worth noting that many NGSO systems restrict transmissions to and from user terminals to elevation angles of thirty-five degrees or more. This limits the relevant field of view

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44 *See NPRM* ¶ 24.

45 *See* Lockheed Martin, "Space Fence," *available at* http://www.lockheedmartin.com/us/products/space-fence html.

46 *See NPRM* ¶ 26.

for each system, and thereby reduces the area over which in-line events can occur. Reducing the separation trigger would have the effect of further reducing the number of such events, while increasing the trigger would have the opposite effect. SpaceX does not favor increasing the trigger angle, as that would further complicate spectrum sharing and is not necessary for the reasons discussed below.

However, a reduction in the separation angle trigger would require NGSO operators to deploy earth station antennas with very high gain and operating power to achieve the necessary signal discrimination for satellites that are closer together, from the earth station's perspective. The sophisticated phased array antennas that will be deployed with NGSO systems can achieve such high-gain performance, but this level of performance would increase price points and complicate form factors to a degree that would effectively preclude low-price terminals for consumer service offerings. For example, SpaceX anticipates deploying consumer equipment that will include antennas with approximately 30 dB gain, which is sufficient to support a ten-degree trigger but not a smaller separation value without creating a risk of harmful interference.

Gateways and enterprise end-user terminals may be able to absorb the added equipment cost required to achieve much higher gain levels needed to support a lower trigger angle. However, that added cost would undermine lower-cost, mass-market consumer services. Thus, decreasing the spacing trigger would decrease the ability of NGSO FSS operators to offer affordable consumer terminals and consumer-oriented satellite broadband service.

To be clear, operators whose system parameters could support a trigger with less separation – such as operators that target only the enterprise market, or where both operate only large gateway antennas – could agree to an alternative bilateral spectrum sharing arrangement with a smaller separation angle that reflects their systems' capabilities, and would likely have an incentive to do

so. However, the Commission should not set the separation angle trigger at a reduced level that would effectively compromise direct-to-consumer satellite broadband offerings from NGSO FSS systems.

V. THE COMMISSION SHOULD APPLY INTERNATIONAL EPFD LIMITS TO ADDITIONAL PORTIONS OF THE KA-BAND

The ITU has adopted power limits for NGSO FSS satellite systems operating in Ku- and Ka-band spectrum, set forth in Article 22 of the ITU Radio Regulations in the form of uplink, downlink, and inter-satellite EPFD limitations. These limits are designed to facilitate NGSO systems' shared use of spectrum with GSO satellite networks. Under the ITU's rules, an NGSO system that complies with these limits is deemed to protect GSO satellite systems, and therefore deemed coordinated.[47] The Commission has adopted the international EPFD limits into its rules for NGSO FSS operation, but only with respect to uplink and downlink transmissions in the Ku-band (10.7-14.5 GHz).[48] The *NPRM* proposes to adopt the international EPFD limits applicable to NGSO uplinks and downlinks in the portions of the Ka-band where NGSO operations are authorized or proposed to be authorized, and to inter-satellite transmissions in both the Ku- and Ka-bands.[49]

SpaceX supports this proposal. NGSO FSS systems are inherently international in nature, and thus as a practical matter must already comply with the applicable EPFD limits in the ITU Radio Regulations. Indeed, all applicants in the ongoing Ka-band NGSO processing round submitted EPFD compliance showings for spectrum outside the Ku-band.[50] The Commission also

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47 ITU Radio Regulations No. 22.5I.

48 *See* 47 C.F.R. §§ 25.146, 25.208(g)-(m).

49 *See NPRM* ¶ 19.

50 *See, e.g.*, SpaceX NGSO Application, Technical Attachment at 36-41 and Annexes 1 and 2.

has granted NGSO systems authority to operate on a non-interference basis in spectrum outside that designated for primary NGSO use based on demonstrated compliance with these limits.[51] These international limits have thus become *de facto* domestic limits as well, which has the added benefit of enabling global NGSO systems to implement a common strategy for system design and operation in all areas of the world.

SpaceX agrees with the Commission's conclusion that compliance with these EPFD limits will be sufficient for NGSO FSS systems to protect GSO FSS networks.[52] Accordingly, adopting the international EPFD regime will further streamline domestic coordination among NGSO and GSO systems. Generally speaking, in order for an NGSO system to comply with the EPFD limits (for both uplink and downlink), it must ensure that there is sufficient angular separation between the transmissions from the NGSO satellites (in the downlink bands) and user earth stations (in the uplink bands) relative to the potential victim GSO earth stations (in the downlink bands) and satellites (in the uplink bands), respectively. The techniques used to protect GSO satellite networks from interference from NGSO transmissions also have the effect of protecting the NGSO system from GSO interference, as they are based on the principle of avoiding inline and near-inline events. Thus, an EPFD regime promotes harmonious inter-system co-existence.[53]

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[51] *See, e.g., Northrop Grumman*, ¶¶ 73-75; *contactMEO Communications, LLC*, 21 FCC Rcd. 4035, ¶¶ 24-26 (IB 2006); *O3b Limited,* IBFS File No. SAT-LOI-20141029-00118, Grant Stamp at Condition 4(b).

[52] *NPRM* ¶ 19.

[53] Nonetheless, the Commission should carefully consider whether it is appropriate to simply import all aspects of its procedural rules for applying these EPFD limits in the Ku-band to the Ka-band. Specifically, by incorporating the new requirements into the existing structure of Section 25.208, the Commission carries forward the compliance showing rules in Section 25.146. Those requirements, adopted for a band characterized by much denser GSO satellite deployment and much older technology, may not be appropriate for the Ka-band.

VI. THE COMMISSION SHOULD MODIFY ITS GEOGRAPHIC COVERAGE REQUIREMENTS

Section 25.145(c) and Section 25.146(i) establish geographic coverage requirements for NGSO systems operating in the Ka-band (18.8-19.3 GHz and 28.6-29.1 GHz) and Ku-band (10.7-14.5 GHz), respectively. They are essentially the same for both frequency bands, and require the applicant to demonstrate that:

(1) the proposed system is capable of providing Fixed-Satellite Service on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands; and

(2) the proposed system is capable of providing Fixed-Satellite Service to all locations as far north as 70° North Latitude and as far south as 55° South Latitude for at least 75 percent of every 24-hour period.

The Commission proposes to eliminate the global coverage requirements in the second prong of each rule "in order to provide operators greater flexibility to design their systems to meet market demands."[54]

SpaceX supports this proposal, as far as it goes. As the *NPRM* notes, the international coverage requirement effectively precludes certain NGSO system designs.[55] For example, NGSO systems that operate near the plane of the equator may not be able to provide service in high-latitude regions, while systems that concentrate coverage at the poles or in a particular region of the world may not be able to provide service to "all locations" in the required area. Thus, the rule may not accommodate an innovative NGSO design that would meet an identifiable market need. As a result, the Commission has issued waivers where strict application of this rule would have been counterproductive. For example, the Commission granted O3b a waiver of this rule because

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[54] *NPRM* ¶ 35.

[55] *See id.* and n.87.

the O3b system "operates in an equatorial orbit as opposed to inclined orbit and as a result, due to look angle constraints, there is a limitation on the northernmost and southernmost latitudes that can be served by its system."[56] Boeing has requested a waiver for its proposed NGSO system, which is designed to focus coverage on major landmasses and therefore leaves portions of the globe (especially in central ocean regions) unserved.[57] Space Norway, which has proposed an NGSO system focused on providing service in the Arctic region, has sought a similar waiver.[58] These specialized systems would not satisfy the Commission's requirement for generalized coverage.

Such a rule might have made sense at a time when global connectivity provided by NGSO and GSO satellites and undersea fiber cables was less well developed, but it now serves more as a potential deterrent to innovation. Moreover, by adopting rules that encourage efficient spectrum sharing among NGSO systems, the Commission ensures that the use of valuable resources to serve one portion of the globe will not preclude their use by another system to serve other areas.

Yet the same arguments apply with respect to the domestic coverage requirement in the first prong of these rules as well. In particular, the northernmost portion of Alaska extends above even the 70º North Latitude requirement for international coverage. Providing service on a continuous basis at such extreme latitudes requires NGSO satellites operating in a highly inclined orbital plane – which could impose a significant cost to achieve coverage that may not fit the business plan of the system's operator. On the other hand, as mentioned above, Space Norway has proposed an NGSO system specifically designed to provide pan-Arctic service to areas above

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[56] Grant Stamp, IBFS File Nos. SAT-LOI-20141029-00118 and SAT-AMD-20150115-00004, ¶ 14 (first issued Jan. 22, 2015).

[57] *See* IBFS File No. SAT-LOA-20151115-00109 (Boeing Application at 37-39).

[58] *See* IBFS File No. SAT-LOI-20151115-00111 (Space Norway Petition at 11-12).

55º North Latitude (including Alaska), which is not capable of providing continuous service to the rest of the United States. Here again, the ability of multiple NGSO FSS systems to share spectrum makes a coverage requirement for any one system unnecessary from a spectrum management perspective.

The domestic prong of the rule has its origin in the 1994 decision establishing service rules for "Big LEO" systems operating in the 1.6/2.4 GHz bands. Specifically, the Commission determined that such systems should be required to provide service on a continuous basis throughout the fifty states, Puerto Rico, and the U.S. Virgin Islands, and defined such operations to require that "at least one satellite will be visible above the horizon at an elevation angle of at least 5º at all times."[59] When the Commission subsequently considered a domestic coverage requirement for Ka-band NGSO FSS systems, it decided to adopt the Big LEO standard – but did so by keeping the qualitative requirement (continuous coverage of certain areas) but omitting the quantitative description of what that entailed (at least one satellite visible above 5º).[60] To the extent that an NGSO system provides service only at a much higher elevation angle, this omission creates a much more burdensome coverage requirement. At a minimum, the Commission should take this opportunity to recognize the effect of this omission, and revise its domestic coverage rule so that it does not impose undue constraints on NGSO system design. SpaceX submits that there is no need for domestic *or* international coverage requirements for the reasons discussed above, and urges the Commission to eliminate them both.

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[59] *Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, 9 FCC Rcd. 5936, ¶¶ 24-25 (1994); 47 C.F.R. § 25.143(b)(2)(iii).

[60] *See Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band*, 12 FCC Rcd. 22310, ¶ 34 (1997). This approach was then applied to Ku-band NGSO systems as well. *See Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, 17 FCC Rcd. 7841, ¶ 63 (2002).

VII. THE COMMISSION SHOULD ADOPT OTHER RULES TO FACILITATE SPECTRUM SHARING

The *NPRM* asks whether there are additional technical rules or other means by which the Commission can facilitate additional sharing in the bands allocated for NGSO FSS use.[61] Under the avoidance of in-line interference events regime, NGSO systems are allowed to use all authorized spectrum except when their satellites and earth stations align in a specified manner – at which point they revert by default to band segmentation in the absence of a coordinated arrangement.[62] This will put a high premium on successful spectrum coordination among NGSO FSS systems. In addition, NGSO system operators must also share spectrum with GSO and terrestrial systems, and must protect operations in nearby spectrum for services such as Radio Astronomy. The ability to share available spectrum in an efficient manner will be a crucial prerequisite to enabling NGSO FSS systems to optimize broadband speeds and increase broadband availability for customers in the U.S. and around the world.

Fortunately, many of the technological advances being incorporated into NGSO system designs also create operational flexibility that can facilitate spectrum coordination. For example, phased array antennas and adaptive beam-forming strategies allow satellites to target narrow coverage areas more precisely while enabling earth stations to track satellites moving through the sky and then seamlessly transition to the next one appearing over the service horizon. More powerful computing and software capabilities enable operators to allocate resources in real time, so that capacity can be placed where it is most needed and energy can be directed away from areas where it might cause interference to other spectrum users. A system design that allows a customer

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61 *NPRM* ¶ 17.

62 *See, e.g.*, 47 C.F.R. § 25.261 (Ka-band spectrum); *Ku-band NGSO Sharing Order*, ¶¶ 52-55; *Ka-band NGSO Sharing Order*, ¶¶ 18-21.

to be served by more than one satellite at a time (a concept called "satellite diversity") enables the operator to determine which specific satellite to use based on whether it would cause or receive interference from a satellite of another system.[63] NGSO systems with these sorts of on-orbit flexibility present more options for potential spectrum sharing strategies than do less advanced systems whose operational capabilities are more constrained.

In the context of NGSO processing rounds, the Commission has recognized that spectrum sharing policies should incorporate sufficient flexibility to promote and accommodate spectrum coordination among operating systems.[64] However, the Commission has not yet considered rules to encourage such features in NGSO systems. One approach to promote that goal would be to adopt rules that can create incentives for NGSO operators to design their systems with a range of advanced capabilities that facilitate spectrum sharing. For example, the Commission could adopt a rule under which an NGSO system that has steerable downlink beams would be entitled to a greater share of commonly-used spectrum during in-line events involving a system that has fixed beams. Similarly, the Commission could establish a safe harbor downlink beamwidth in each frequency band, and any operator whose system used beams too large to fall into that safe harbor would be entitled to proportionately less spectrum during in-line events involving a system that had compliant beams.[65] Or it could adopt a rule under which an NGSO system with a high level of satellite diversity would be entitled to use more spectrum during in-line events than a system that has little or no overlap of satellite coverage areas.

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[63] As explained by the Commission, "[w]ith satellite diversity, NGSO FSS systems can avoid an in-line interference event by selecting another visible satellite within their system constellation (performing a hand-over process) whenever the current satellite approaches the in-line event with a satellite operating in another NGSO FSS system constellation." *Ka-band NGSO Sharing Order*, ¶ 44.

[64] *See, e.g., Ku-band NGSO Sharing Order*, ¶¶ 9, 27.

[65] For example, an operator whose downlink beams were 50% larger than the safe harbor beamwidth would default to a 40%/60% split of spectrum with a system using compliant beams.

Efficient spectrum sharing will be essential to the success of all NGSO FSS systems. The Commission's rules should reward those systems that facilitate such sharing, as they benefit all NGSO FSS operators and enable them to make more efficient use of valuable spectrum resources.

CONCLUSION

SpaceX applauds the Commission for undertaking this review of its rules for NGSO FSS systems, many of which have been in place for over a decade and no longer make sense in light of current technology and operating conditions. By implementing the proposals discussed above, the Commission can update its regulatory framework in a way that will help unlock the potential of NGSO FSS systems to make intensive use of valuable spectrum resources to provide advanced services to customers in the U.S. and around the world.

Respectfully submitted,

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